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A PROBLEM IN SYSTEMS ANALYSIS

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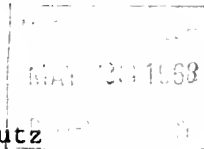
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## CITY MANAGEMENT--A PROBLEM IN SYSTEMS ANALYSIS

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"What must we do between now and the year 2000 to make the city responsive to man's needs?" Implicit in this question posed by the sponsors of this conference, is the assumption that cities can be made to respond to man--that man is capable of molding the facilities, institutions, and human processes that together constitute a modern metropolis.

### Can Man Control his Cities?

Are these reasonable assumptions? Can man control the evolution of a major metropolitan area? Is man capable of comprehending and relating the myriad elements and subtle interactions that cause a city to grow, to prosper, and to serve the needs of its residents? Or, is man no longer capable of understanding or regulating his environment? Are we destined to see our cities careening out of control toward destruction? The dynamic process of a large city frequently appears unstable, allowing a sensitive observer to perceive the rudiments of self destruction within the city's unrestrained growth.

Concern for the life and death of a city is not new. In the seventeen hundreds, Oliver Goldsmith expressed his apprehension.

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\*A talk prepared for presentation at the M.I.T. Southwest Regional Conference in Dallas, Texas, March 30, 1968.





"What cities, as great as this; have promised themselves immortality! Prosperity can hardly trace the situation of some. The sorrowful traveller wanders over the awful ruins of others ... Here stood their citadel, but now the haunt of every noxious reptile; temples and theatres stood here, now only an undistinguished heap of ruins."<sup>1</sup>

In recent months anxiety regarding the future of our cities has been openly expressed. In November, a headline in U.S. News and World Report asked the fundamental question, "Can today's cities survive?"<sup>2</sup> In January, the editors of Fortune devoted an entire issue to "The Urban Crisis". They talked of a nation that has often lived dangerously standing once more at the volcano's rim.

"The whole world knows the condition of U.S. cities and has known it for decades. The billions we have poured out for foreign aid and propaganda, the more numerous billions we spent for military support of our foreign policy, are half canceled by the damage that is done to U.S. prestige by a long-standing inability to deal effectively with gangsterism, slums, high infant death rates among our poor, traffic jams, junk yards, bill boards, and all the rest of the noxious mess. What, much of the world asks, is the point of being the richest and most powerful nation, if such problems can't be handled better? What is the point of capitalism? Of democracy?"<sup>3</sup>

The city may be among the most formidably complex interactive systems that man can attempt to control. And, as is painfully obvious, the problems will not become less complex. When the American Academy's Commission on the Year 2000 examined the topic we are today considering some of its members predicted the expansion

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<sup>1</sup> The Bee No. 4, Oliver Goldsmith, 1759.

<sup>2</sup> U.S. News and World Report, November 6, 1967.

<sup>3</sup> "The Deeper Shame of the Cities" Fortune, January 1968, pp. 132-133.



of currently existing metropolitan areas into three "gargantuan megalopolises", labeled Boswash, Chipitts, and Sansan. Boswash identifies a megalopolis extending from Washington to Boston and containing almost one quarter of the U.S. population. Chipitts is expected to encompass the area from Chicago to Pittsburgh and north to Canada, thereby including Detroit, Toledo, Cleveland, Akron, Buffalo and Rochester. Sansan will stretch from Santa Barbara to San Francisco to San Diego and comprise approximately 20 million people.<sup>4</sup> In the opinion of these prognosticators, the megalopolis phenomena will be typical of other countries as well. They predict that between 80 and 90 per cent of the population of the developed world will be urbanized by the end of the century.

If these megalopolises are not to decay as rapidly as they expand, we must develop new approaches to the management of the city. It is no longer realistic to append suburbs to cities, extensions to thruways, or advisory boards to municipal governments, and expect these actions to produce more effective response to man's needs. Rather, we must develop new and relevant decision frameworks and organization structures appropriate for the control of the increasingly complex interactive social, economic, and political systems.

In 1966 the Mayor's Task Force on Reorganization of New York City Government presented a proposal, since implemented, to restructure the functional organization of America's largest city.

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<sup>4</sup> "A Framework for Speculation" Herman Kahn, and Anthony Wiener Daedalus, Summer 1967, pp. 718-719.



In the introduction to this report the Task Force stated,

"If a modern city is to be governable it must possess three crucial assets:

1. The will to act;
2. The necessary human and monetary resources;
3. The administrative machinery to bring the first three assets to bear on its problems.

The increasing complexity of modern urban problems calls for more imaginative and creative development of policies, and this in turn requires more sophisticated tools of government to formulate and execute these policies in a coordinated, effective manner."<sup>5</sup>

#### Managing Complexity Through Systems Analysis

Certainly a concerned populace has the will to act, and the resources of our larger cities are vast. But what kind of administrative machinery is required? What are the "sophisticated tools" which men might use to structure and solve the complex problems of a city? While emphasizing the scope and intensity of the crisis, the previously noted issue of Fortune described one hopeful sign that man may yet learn to manage his cities.

"In cities all over the U.S., police captains, garbage collectors, prison wardens, health officers, highway administrators, welfare workers, and other toilers in the urban bureaucracy are getting the feeling that strange

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<sup>5</sup> The Mayor's Task Force on Reorganization of New York City Government, Report and proposed local law, City of New York, December 1966, p. 1.



men are looking over their shoulders. The strangers speak an odd jargon, spend days digging into musty files, prowling the offices asking prying questions. Their behavior is mystifying, sometimes irritating, to tradition-bound bureaucrats. But they represent one of the best hopes that have so far turned up for bringing orderly solutions to the disorderly problems of the city."

"The strange intruders are systems engineers, ... (and) they are trying to apply the techniques developed in building missiles and spacecraft to the down-to-earth problems that grow out of the way people live together."

"Historically, cities have grown by random accretion, the result of hundreds of thousands of individual decisions by private builders and public agencies, largely unrelated to one another except by accident. Systems engineering would take a different tack. It would examine the city in the round as a total systems complex, interrelating all its demographic, economic, social, and physical components, with a view to arriving at more integrated solutions to the multiple problems."<sup>6</sup>

### What is Systems Analysis?

Not surprisingly, systems analysis is a process for analyzing systems. The concept of analysis is well understood. We use the word analysis to refer to the process by which a problem or entity is separated into constituent parts--literally unloosened or resolved into elements. Systems analysis might, therefore, be defined as the examination of systems to distinguish their component parts and elements separately or in relation to the whole. The real question is - "What is a system?" The year-book for the advancement of general systems theory provides the following

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<sup>6</sup> Systems engineering invades the city, Fortune, January 1968, pp. 155-157.





definition:

A system is a set of objects together with relationships between the objects and between their attributes.<sup>7</sup>

Another source indicates that "a system is an organized or complex whole; an assemblage or combination of things or parts forming a complex or unitary whole."<sup>8</sup>

The word system can thus connote a plan, method, structure, framework, sequence or organization. These definitions suggest that the application of systems analysis to the problem of the city will involve an examination of the elements and relationships which make up the "city system".

The system analyst proposes to approach the complexities of the city by structuring existing knowledge and assumptions in a series of assertions that may be verified through testing. The alternative is to be content with intuitive decision processes based on perceptions that cannot be evaluated because they have never been explicitly communicated.

Starting with the perceptions of managers and observers of the city environment, the system analyst attempts to structure the insights of informed individuals so that they may be communicated with a minimum of ambiguity. His goal is to produce a usable representation--one that can be objectively verified or rejected

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<sup>7</sup> "The Definition of Systems", Year-book for the Advancement of General Systems, 1956, p. 18.

<sup>8</sup> Richard A. Johnson et.al., "The Theory and Management of Systems", McGraw Hill Book Co., New York, 1963, p. 4.



with reference to data from the real world.

It is difficult to find fault with these objectives. Most city administrators agree that it is desirable to develop structures within which the implications of factors influencing complex management decisions may be analyzed. However, although systems analysis "makes all kinds of sense" as a general approach to large scale management problems, they frequently insist, "special considerations" make it inapplicable to their city at this time. Why? I would suggest that human rather than technological reasons have impeded the broad application of systems analysis.

#### The Problem of Management Involvement

Management must be involved in the systems analysis process. A technical staff may handle the details of documentation and programming. However, management must determine the scope and focus of analysis and insure that prevailing conditions are represented by valid measures of executive action and environmental response. Only management can establish meaningful priorities, criteria, measurements, decision procedures, and standards of evaluation.

Systems analysis focuses on the processes which management is attempting to influence. Systems are not designed by asking management to list "the kinds of information you would like to have?" or "your ten most important decisions?" Discussions of existing reports and decision procedures have little to do with systems analysis.



Systems analysis begins with the manager's representation of the the city. The process challenges the executive to describe the environment he is attempting to influence. This perspective should be emphasized. Systems analysis focuses on the environment to be influenced through decisions not the decisions themselves.

### The Problem of Being Explicit

Abstraction is inherent in systems analysis. The individual who develops a model must impose structure on a situation. He must specify that which is relevant. This requirement is not unique to systems analysis. Whether or not a decision maker develops an explicit model, the information considered in reaching a decision is determined by his limited perception of the decision environment. We are all familiar with the observation "... it seems to me that this is basically a matter of ...," which frequently precedes presentation of highly abstract verbal ideas. Subjective evaluation is present whether or not an explicit model is established. However, as a representation is made explicit, the level of abstraction--the level to which the model builder has reduced the situation to a limited and manageable number of factors--becomes more obvious.

The perceptiveness of the individual who has the ability to "separate the wheat from the chaff" and "get to the nub of the problem" is often lauded. Yet, when this same perception is applied to the structuring of an explicit decision model through exclusion of other



than the most relevant factors, the results may appear appallingly "simple minded" and be dismissed as "naive" or "sophomoric".

Seasoned managers may become unnerved when asked to summarize factors considered in arriving at a decision and to make explicit the assumptions underlying their choice of factors. The resultant "model" is usually a simple one, and the manager is seldom happy with it. It is disturbing to recognize that a decision affecting an expenditure of tens of millions of dollars in a complex municipal environment is made on the basis of a model that takes into account only two or three vaguely specified concepts.

It is even more distasteful to admit that a direct relationship has been assumed between ill-defined descriptors and a complex outcome. It is far more satisfying to retain the aura of understanding that follows ambiguous general discussion than to face the frustrations inherent in being specific. Systems analysis is rightly viewed as a vehicle for the creation of dissent. Those promoting systems analysis are trouble makers. They challenge the comfortable platitudes and question the bases of time honored decision rules. It is, therefore, not surprising to find that human reactions present more significant barriers to successful system analysis than any technical consideration that can be identified. The systems analyst must assume one of the most influential yet ill-defined roles in the management structure. He is an agent of change.





### The City as a System

If the city is to be viewed as a system we must establish a conceptual framework, a skeletal structure to which the elements relevant to city management may be attached. This conceptual framework must:

1. Define a set of elements that, while common to a broad range of management problems, are defined in sufficient detail to permit differentiation between relevant states of the environment.
2. Serve as a basis for description of processes as well as of elements--provide a means of describing interactions between elements.
3. Be based on measurable entities amenable to quantitative description and validation.

A city can be described in many diverse ways and depicted in conflicting word pictures. One can, for example, consider the organization structure of a municipality. This was the focus of the previously mentioned New York City Task Force. From this perspective they concluded that "... New York City, confronted by municipal problems of enormous magnitude, beset by pressures of incredible intricacy, simply does not possess administrative machinery adequate to this task of conducting its business effectively."<sup>9</sup> Their conclusions were summarized in a structure, an administrative system, designed to be "... supple enough to be readily responsive to the policy decisions of the city's elected leaders and efficient enough to deliver municipal services to its people when and where needed without waste of money or time."<sup>10</sup>

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<sup>9</sup> Op.cit., Footnote 5, p. 1.

<sup>10</sup> Op.cit., Footnote 5, p. 1.



The organization chart (Figure 1) summarizing the proposed agency structure illustrates the complexity of this aspect of the city system. Moreover, it is important to note that each box on the organization chart represents a complex sub-system itself worthy of systems analysis. The Health Service Administration, for example, was to encompass the activities of four previous departments. The Task Force found that the previous fragmentation of Health Services Administration into several departments had wasted resources in duplication and inefficient utilization and seriously impaired the city's ability to bring these resources to bear effectively to meet its needs. In creating the new centralized agency, the Task Force hoped to establish an administration with the capacity to perform long range planning and to apply modern methods of analysis to the coordinated direction of health services. But how does one go about managing the complex responsibilities of this department? How does one develop, implement, and evaluate a coherent program that will integrate the clinical, preventive, and mental health services of a great city?

#### An Application of Systems Analysis

Last Sunday's New York Times quoted Dr. Cesar A. Caceres of HEW's Medical Systems Development Laboratory as follows:

"We must bring systems analysis to health services just as it has successfully been focused on military and industrial problems. The need, the supply, and the delivery of health services must be viewed broadly as a total system, not as a series of unrelated bits and pieces."<sup>11</sup>

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<sup>11</sup> The New York Times, Sunday, March 24, 1968, p. F-5.



Before attempting to view the environment controlled by the Health Services Administration as a composite whole, we must create a framework for analysis. This framework or structure will be used to define system elements and to describe interactions among elements.

The human mind is well suited to this type of analytic structuring. We are able to define the parts of a system and describe interactions among a limited number of parts under specified conditions. The human mind is simply incapable of complex synthesis. Fortunately computers are able to perform this job. If we can identify the parts and describe single interactions, the computer can be used to determine what would happen if all interactions among all parts occurred simultaneously as in the real world.

### Elements of the City Health System

An examination of the health services environment suggests four major elements of the city health system. These are:

1. health service facilities
2. doctors
3. the population at large  
and
4. patients treated in the health service facilities.

### Health Service Facilities

Four types of health service facility are encountered in most major metropolitan areas. These are: (1) medical centers, (2) community hospitals, (3) extended and chronic care facilities,



and (4) ambulatory care facilities. Each class of health service facility can be described in terms of several attributes including:

1. geographic location
2. number of beds
3. special and routine equipment
4. doctor availability
5. supporting personnel availability
6. pharmaceutical inventories
7. special unit capability (e.g. cardiac surgical team or renal hemodialysis facility)
8. teaching program
9. budget.

#### Doctors

The population of doctors associated with one or more regions of the health administrator's jurisdiction may be defined in terms of

1. age
2. speciality
3. position (e.g., house, staff or senior physician)
4. stage of training
5. specific qualifications
6. affiliation with specific facility
7. language skill
8. location of practice.





### Population

In describing the people living within the health administrator's jurisdiction, one is primarily concerned with the probable health needs of various population segments. An expected incidence of indication (illness) can be derived from the following attributes:

1. geographic location
2. age
3. sex
4. socio-economic indicators (e.g., income, family size, marital status of head of household, and number of persons per room in dwelling unit).

Although not applicable to the derivation of expected incidence of indication, other factors such as primary language may be relevant to consider in order to assure an effective match between the population and the facilities in a region.

### Patients

Ideally, the health administrator should have access to relevant medical statistics derived from a complete health record for all persons serviced by facilities in his region. From a practical standpoint, access to this level of data is available in only a small fraction of the medical facilities. As an indication of the extent of this problem, the report of the Commission on the Delivery of Personal Health (the Piel Commission) notes that in one municipal medical center patient records are "chronically eighteen months behind."<sup>12</sup>

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<sup>12</sup> Comprehensive Community Health Services for New York City, City of New York, 1967, p. 18.



Working within such constraints, the system analyst might define the patient population in terms of measures (or estimates) of the following type:

1. Geographic location
2. Age
3. Sex
4. Socioeconomic indicators
5. Health service facility interaction
  - a. date of contact
  - b. indications exhibited
  - c. symptoms presented
  - d. treatment perscribed
6. Medical history
  - a. medication currently received
  - b. drug allergies
  - c. outstanding illnesses.

#### Interactions Among System Elements

Once major elements of the medical system have been defined, the systems analyst must describe the dynamic processes involving these elements. For purposes of illustration we will examine four processes occurrring within the health services environment. These are: inter-facility interactions, doctor-facility interactions, patient-facility interactions and facility change.

#### Inter-Facility Interactions

Interactions among health service facilities may be described in terms of the transfer of trained personnel, drugs, equipment and patients. Data describing these processes would ideally be time and indication specific. The Piel Commission Report commented on inter-facility interactions (Figure 2) as follows:



"Health service facilities in a borough or 'region' should be linked by rational allocation of responsibility to form a comprehensive delivery system. Sites of primary care in each community are related to the community hospital. Each community hospital is tied, in turn, to the teaching hospital or medical school that serves as the regional medical center. The medical center, in this model system, also serves as a community hospital backing up the primary care facility of its immediate community."<sup>13</sup>

### Doctor-Facility Interaction

Doctor-facility interactions would ideally encompass determinants of the time and extent of doctor contact with specific facilities and the proportion of doctor time devoted to specific activity.

While the latter data are difficult to acquire, preliminary observations suggest that it would be particularly useful to recognize the allocation of doctor time to such diverse activities as teaching, operating versus follow-up, nursing care, locating patient records, laboratory work, private patient consultations, ward service, emergency service, or out-patient treatment. In the absence of this detail it may be impossible to assess the effectiveness of doctor utilization within many medical facilities.

### Patient-Facility Interaction

Patient interaction with a health facility can be described in terms of

1. time and extent of contact or contacts
2. symptoms presented
3. indications exhibited
4. nature and extent of doctor contact
5. tests given
6. drugs prescribed
7. treatment given.



In evaluating the quality of service provided by a facility, it may also be useful to note the degree of patient satisfaction with services rendered and the doctor's assessment of the effectiveness of treatment and satisfaction with same. In this latter context, we would be concerned with complications of therapy, patient sign-out against medical advice, and the incorrect application of medication within the hospital or home.

Patient-facility interactions were also noted by the Piel Commission.

"The model comprehensive health service system (Figure 3) is shown here as it appears from the point of view of the individual consumer. From the sight of primary care, at the center of the diagram, the system places him within reach of any resource he may need, whether it be the services of the community hospital or medical center or ancillary facilities for chronic and extended care."<sup>14</sup>

#### Facility Change

The systems analysis must encompass processes through which facility attributes are modified over time. This includes, for example, personnel turn-over (extent and rate), capital expansion (equipment and buildings), and renovation of existing facilities.

#### A Health Services Management System

The systems analysis process produces a model of the health services environment. This model may become the basis for an information system through which the Health Services Administrator plans for, monitors, and evaluates his environment. The model identifies the elements and processes through which activity in

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<sup>14</sup> Op.cit., Footnote 12, p.30.





the health services environment is to be described, and specifies the measurements to be included in the information system data bank. Figure 4 illustrates the structure of a health services management information system.

Data-gathering procedures are established to generate information describing the current state of the health services environment using measures developed during system analysis. These measurements are retained in the master data file. The data file serves as the reference source for the information system and provides the historic data base for model initialization.

Management has the ability to interrogate the data file to obtain information regarding the current state of the environment. This basic retrieval functions is described by the set of interactions noted by A in Figure 4. Management's use of the model as a basis for testing proposed programs is illustrated by the interaction set indicated by proposals and model outputs. Proposed plans are communicated to the information system, which establishes hypothetical conditions for the model. Results obtained from the model are then transferred to the information system, which formats them for presentation to management. Following this process, management is able to evaluate the conditional results of proposed programs using the same procedures and equipment employed to assess the current state of the environment through interrogation.

Once policy and strategy have been finalized, the proposed plan and budget are established as references, and model output describing the plan are generated for use by a monitor program.



As plans are implemented in the environment, the monitor program compares actual measures with model outputs indicating the expected results of planned implementation. Significant deviation from plan becomes the criterion for monitor referral to management.

#### System Utilization

The management information system described in Figure 4 is designed to assist health service management in performing the following functions:

1. Monitor the health status and determine the health needs of the population.
2. Establish long-range plans and set standards and objectives for the health service system.
3. Coordinate the use of health resources.
4. Maintain environmental defenses.
5. Monitor the quality of medical care and hospital facilities.
6. Evaluate medical care and health facilities against objective standards.

#### Service Evaluation

The system supports the evaluation of service quality in each facility based on indication or symptom specific analyses of patient-facility interactions. Measures provided include

1. The frequency of interaction
2. The number and appropriateness of consultations
3. The tests given
4. Drugs prescribed
5. Treatments given.



### Patient-Facility Evaluation

The system supports evaluation of the appropriateness of facility attributes by providing region specific analyses of facility availability and utilization by indication.

The compatibility of facilities and population needs may also be assessed by examining the expected, as opposed to exhibited, indications and treatment by indication and facility.

### Incidence Change Evaluation

Data files associated with the system provide the information required to evaluate changes in

1. Incidence of infectious diseases
2. Mortality rates by indication
3. Infant and maternal mortality
4. Traffic mortality (applicable to the evaluation of emergency facilities).

### Cost-Effectiveness Evaluation

With the inclusion of budget data the system supports evaluation of facility cost-effectiveness at the indication level in terms of dollars per patient treated. By combining the budget information with service evaluation data, cost-effectiveness studies are expanded to include measures of the quality as well as extent of service provided by each facility.



### A New Style of City Management

I began this discussion questioning whether man was capable of controlling the evolution of a city. In my opinion he can make the city responsive to his needs if he will structure his environment, establish explicit objectives and criteria of evaluation and utilize the computer to synthesize and maintain a representation of the total environment.

As the computer assumes this function, the manager's role must change. His new job will not involve new or strange activities. It will, however, place a new emphasis on already familiar concerns. Little or no time will be spent in routine analysis, evaluation, or allocation. The procedures to be followed in these "programmable" activities will have been explicitly defined and specified, and authority over them delegated to a computer based system. The executive will thus have time to concern himself with broader policy problems which he will approach with increased effectiveness due to the availability of more meaningful data and an increased (model based) understanding of his environment. He will be concerned with problem definition and will devote substantial time to the broader planning functions which are now often relegated to low priority positions on the executive agenda to make way for fire fighting and crisis curtailment. Much of his time will be spent in increasing his understanding of the environment and in refining his insights into planning and communication processes which are his area of expertise. He will spend substantial time





building models--making explicit, testing, and validating or rejecting hypotheses regarding the nature of his environment and his impact on it.

Freed from the detail of routine commitments and provided with the ability to study the implications of new concepts and approaches, the city executive will have the means to monitor, evaluate and control his expanding environment. He will enjoy a new freedom to experiment with creative ideas and be equipped to responsively apply the resources of Boswash, Chipitts or Sansan to meet man's needs.



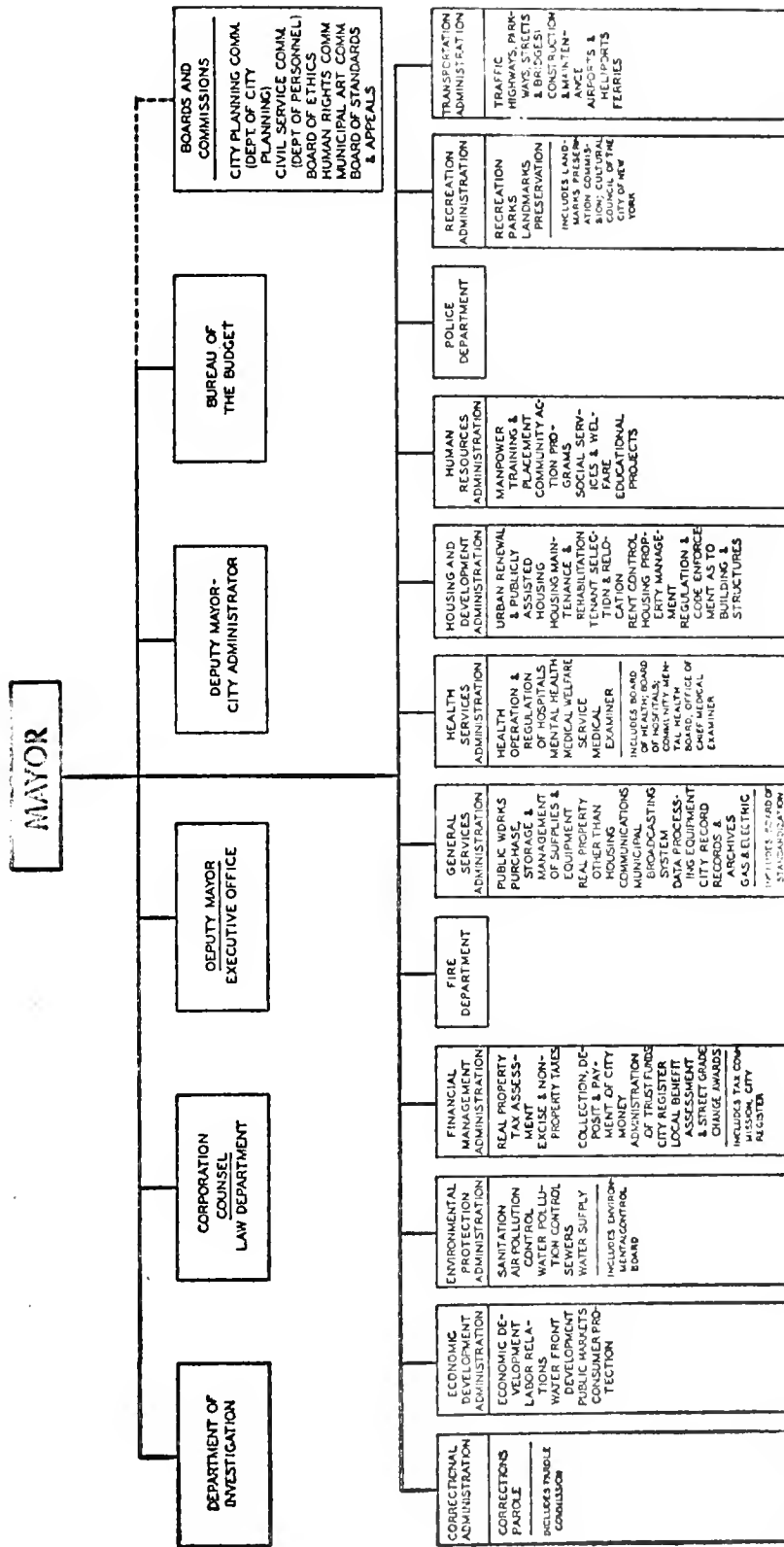
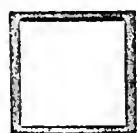
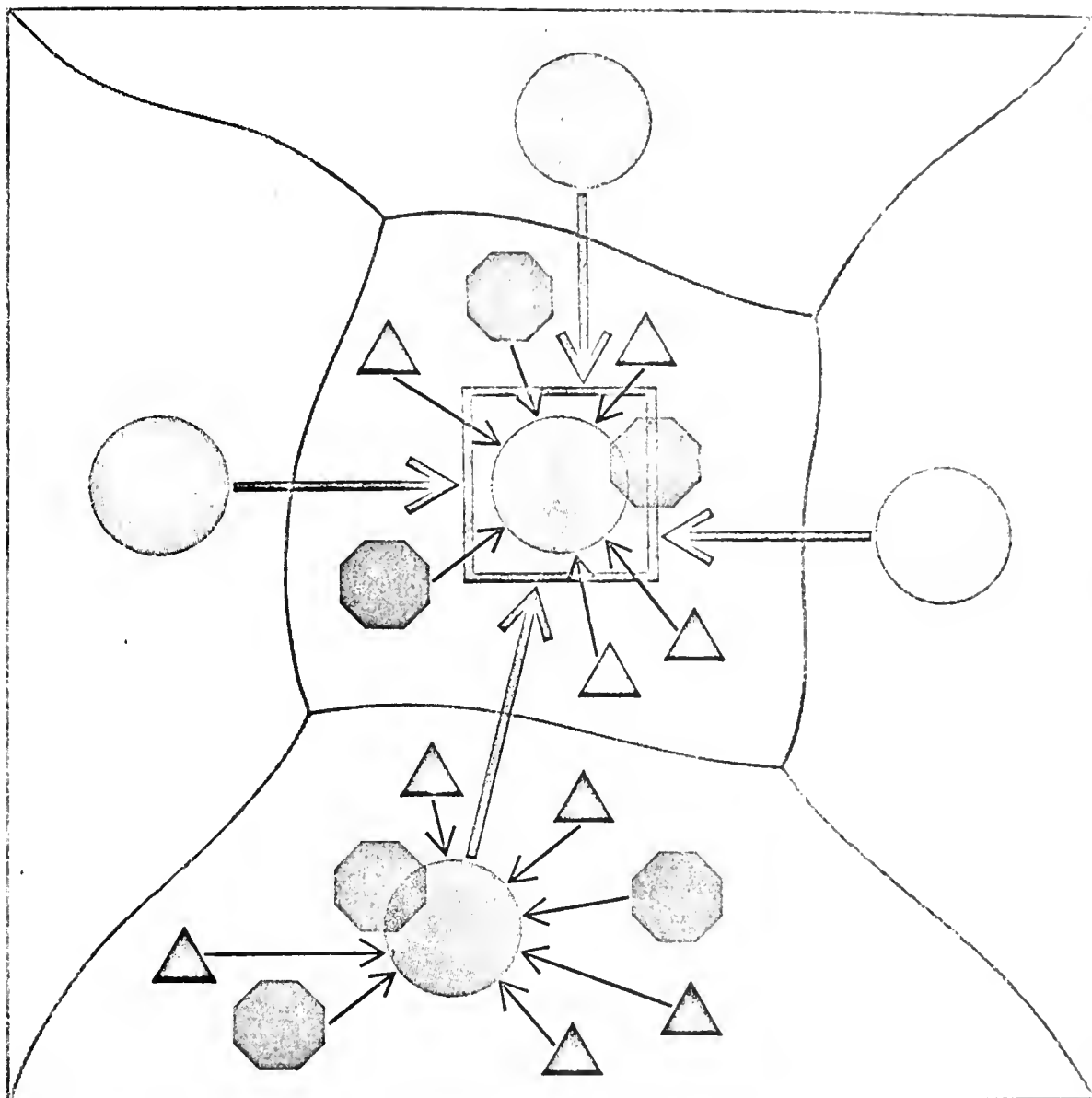
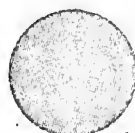


Figure 1





Medical Center



Community Hospital



Extended and Chronic  
Care Facilities



Ambulatory Care  
Facilities

Figure 2



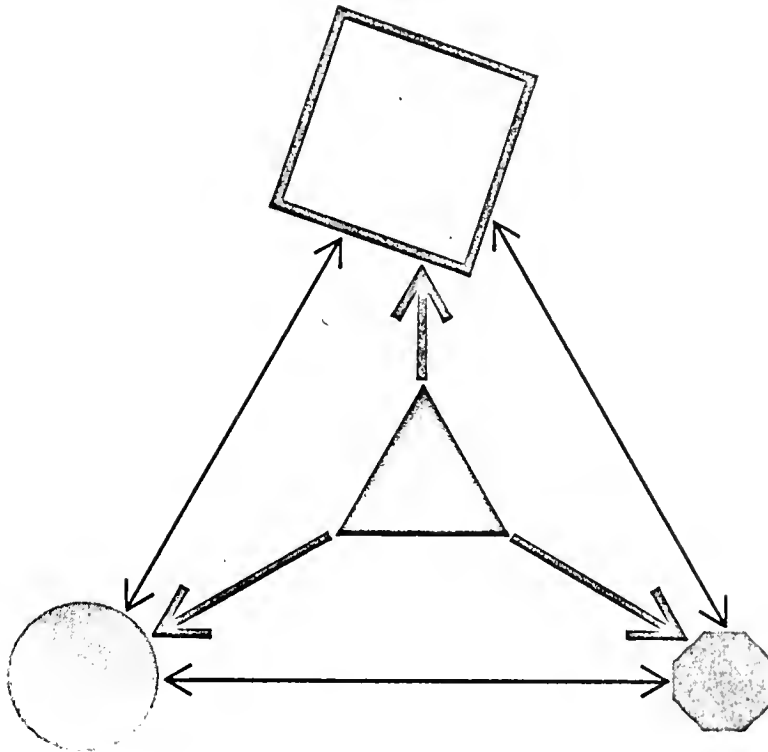


Figure 3





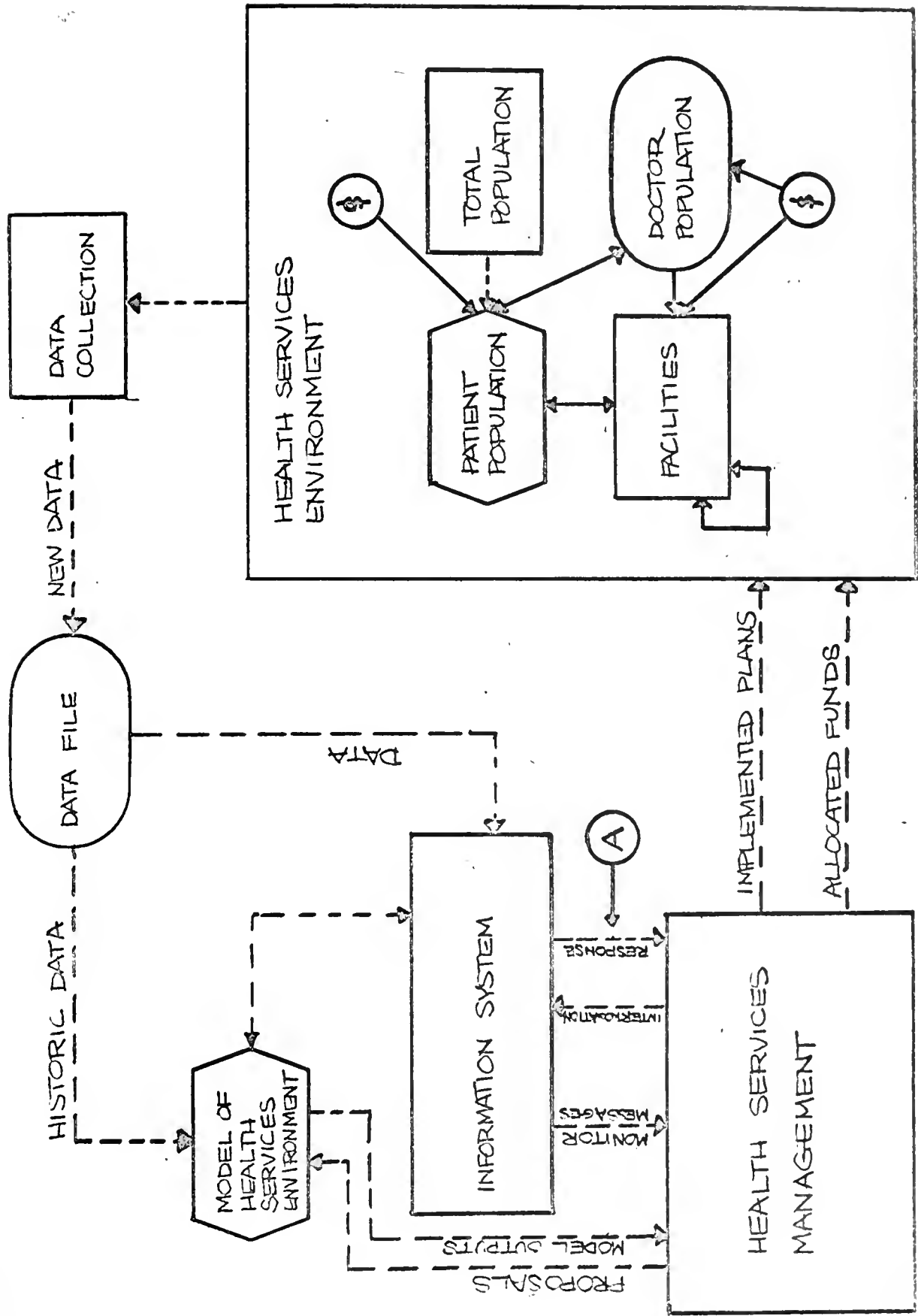


Figure 4









